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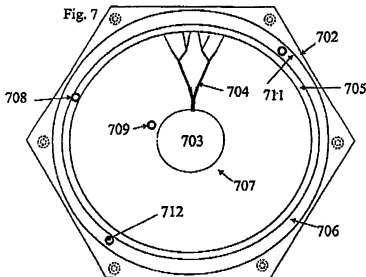
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(54) Title: FUEL CELL OR ELECTROLYSER CONSTRUCTION



(57) Abstract: A fuel cell or electrolyser stack comprises countercurrent radially directed fuel and oxidant flow fields on either side of a membrane electrode assembly. A first reactant may flow radially outwardly from a manifold to a first reactant drain and a second reactant may flow inwardly from the edge of the assembly to a second reactant drain.

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THESE RESULTS WERE OBTAINED BY A STUDY OF THE EFFECTS OF VARIOUS FACTORS ON THE GROWTH OF THE BACTERIA.

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

- as to the identity of the inventor (Rule 4.17(i)) for all designations
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FUEL CELL OR ELECTROLYSER CONSTRUCTION

This invention relates to fuel cells and electrolyzers, and is particularly, although not exclusively, applicable to proton exchange membrane fuel cells and electrolyzers.

- 5 Fuel cells are devices in which a fuel and an oxidant combine in a controlled manner to produce electricity directly. By directly producing electricity without intermediate combustion and generation steps, the electrical efficiency of a fuel cell is higher than using the fuel in a traditional generator. This much is widely known. A fuel cell sounds simple and desirable but many man-years of work have been expended in recent years attempting to produce practical
- 10 fuel cell systems. An electrolyser is effectively a fuel cell in reverse, in which electricity is used to split water into hydrogen and oxygen. Both fuel cells and electrolyzers are likely to become important parts of the so-called "hydrogen economy". In the following, reference is made to fuel cells, but it should be remembered that the same principles apply to electrolyzers.

- One type of fuel cell in commercial production is the so-called proton exchange membrane (PEM) fuel cell [sometimes called polymer electrolyte or solid polymer fuel cells (PEFCs)].
- 15 Such cells use hydrogen as a fuel and comprise an electrically insulating (but ionically conducting) polymer membrane having porous electrodes disposed on both faces. The membrane is typically a fluorosulphonate polymer and the electrodes typically comprise a noble metal catalyst dispersed on a carbonaceous powder substrate. This assembly of electrodes and
- 20 membrane is often referred to as the membrane electrode assembly (MEA).

- Fuel (typically hydrogen) is supplied to one electrode (the anode) where it is oxidised to release electrons to the anode and hydrogen ions to the electrolyte. Oxidant (typically air or oxygen) is supplied to the other electrode (the cathode) where electrons from the cathode combine with the oxygen and the hydrogen ions to produce water. A sub-class of proton exchange membrane
- 25 fuel cell is the direct methanol fuel cell in which methanol is supplied as the fuel. This invention is intended to cover such fuel cells and indeed any other fuel cell using a proton exchange membrane.

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Flow field plate 2 is annular and, as stated above, has a central aperture 403. Fuel inlet 404 leads from the aperture 403 to a humidification section 407. From humidification section 407 a flow field 408 leads to a fuel drain 405. (Only part of the flow field is shown, several channels being provided extending radially outwardly from the humidification section). Aperture 409 passes through the flow field plate 1 and allows aligned apertures 409 in a stack to form an escape route for surplus fuel leading to fuel outlet 6.

Land 406 is configured to receive seals and this configuration may take place either with the formation of the flow field or in a separate step.

The oxidant flow field on the underside of flow field plate 2 is the reverse, with oxidant flowing radially inwardly from the outer edge of the flow field plate 402 to an inner drain 407 which connects with aperture 410. Aligned apertures 410 in a stack form an escape route for surplus oxidant leading to oxidant outlet 7. Coolant channel 411 runs from coolant inlet aperture 412 to coolant outlet aperture 413. Aligned coolant inlet apertures 412 in adjacent plates serve to receive coolant from coolant inlet 8 and aligned coolant outlet apertures 413 in adjacent plates serve to pass coolant to coolant outlet 9.

Coolant channel 411 is disposed to lie opposite humidification section 407 of the adjacent flow field plate. By placing a water permeable membrane between the coolant channel 411 and humidification channel 407 incoming hydrogen can be humidified. Sufficient humidification to prevent the membrane drying out is required.

A similar arrangement can be used to humidify incoming oxidant, using a coolant track on the fuel side of the opposed flow field plate. The need for humidification on the oxidant side is less than on the fuel side since water is produced on the oxidant side of the membrane electrode assembly. Some humidification of the oxidant is desirable (to prevent loss of water in the region where the oxidant enters the membrane) but too much humidification is undesirable, as this limits the water carrying capacity of the oxidant.

The water permeable membrane can be e.g. a thin film silicon rubber. The membrane of the membrane electrode assembly could be used in this role.

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The pressure of oxidant in the void space 104 will serve to press down on the stack in the direction of arrow "A" in Fig. 1. The pressure of gas within the stack will press outwardly of the stack in the direction "B", tending to separate the plates of the stack. The compressive force in the direction "A" will tend to counteract the pressure of gas in the direction "B". Indeed, if the pressures and areas of application are chosen appropriately it is possible for the stack to be under compression. This principle can also be applied to a single stack in a chamber, as well as multiple stacks as exemplified.

Of course the whole arrangement can be reversed (oxidant up the middle and fuel at the outside) but for safety reasons the arrangement shown is preferred.

The arrangement described and illustrated is not limited to circular flow field plates, although conventional flow field plates are rectangular in form which gives rise to problems with sealing at the corners. A circular or oval geometry for the seals may be advantageous. A circular arrangement is not ideal for aligning however, and as shown in Figs. 4 and 5 a hexagonal plate could conveniently be used with fixing holes at the corners to receive threaded rods or other means for aligning or securing the stack. However, as the pressure of gas within the stack is at least partially compensated by the pressure outside the stack, relatively light securing means can be used.

The radial gas flow arrangement of Figs. 4-6 is advantageous for several reasons. Firstly one has a countercurrent flow between the fuel and the oxidant which maintains a relatively even pressure differential across the membrane electrode compared with conventional bipolars, which tend to have a cross-flow arrangement. Such a relatively even pressure differential means that the membrane is under a relatively reduced stress. Secondly, the pressure is more evenly distributed across the width of the stack and this means that the forces acting on the bipolar plates are evenly distributed, lessening the risk of a plate breaking or deforming. Further, the evenness of pressure distribution leads to an improved uniformity of electricity generation across the membrane electrode.

Fig. 7 shows such a different form of radial countercurrent flow field bipolar, in which flow field plate 702 is hexagonal annular in form having a fuel supply aperture 703. Branching flow field pattern 704 (part shown) connects fuel supply aperture 703 to a fuel drain 705 which leads to fuel drainage port 708. Land 706 is configured to receive seals and this configuration may take place either with the formation of the flow field or in a separate step.

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The oxidant flow field on the adjacent flow field plate is the reverse, with oxidant flowing in from the outer edge of the flow field plate to an inner drain communicating with oxidant drain port 709. On the reverse of the oxidant flow field plate is a coolant track. Coolant inlet port 711 communicates via this coolant track to coolant outlet port 712.

- 5 In this arrangement the fuel flow is divergent and the oxidant flow is convergent so providing a counter-current radially directed fluid flow each side of the membrane electrode (using "radial" in the sense of moving towards or radiating from a point and not in the limited sense of referring to the radius of a circle). Preferred materials for the plate are graphite, carbon-carbon composites, or carbon-resin composites. However the invention is not restricted to these
- 10 materials and may be used for any material of suitable physical characteristics.

The separate integers and combinations described above may form inventions in their own right.

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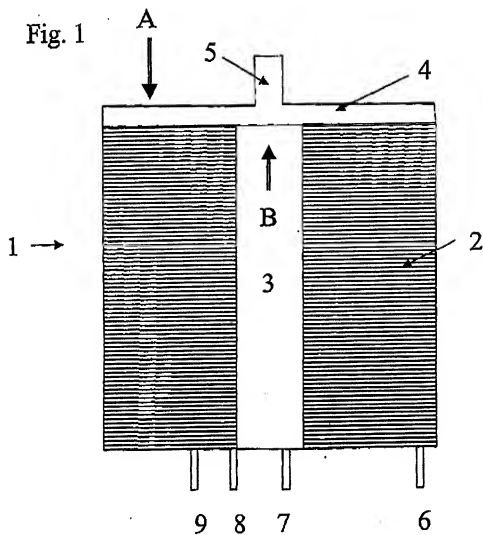
CLAIMS

1. A fuel cell or electrolyser assembly having countercurrent radially directed fuel and oxidant flow fields on either side of a membrane electrode assembly.
- 5 2. A fuel cell or electrolyser assembly, as claimed in Claim 1, in which a first reactant gas flows radially outwardly from a manifold to a first reactant drain and a second reactant gas flows inwardly from the edge of the assembly to a second reactant drain.
3. A fuel cell or electrolyser assembly, as claimed in Claim 1 or Claim 2, in which incoming gas on a flow field plate urges a sealing ring towards a sealing groove on an adjacent flow field plate maintained at relatively low pressure with respect to the incoming gas.
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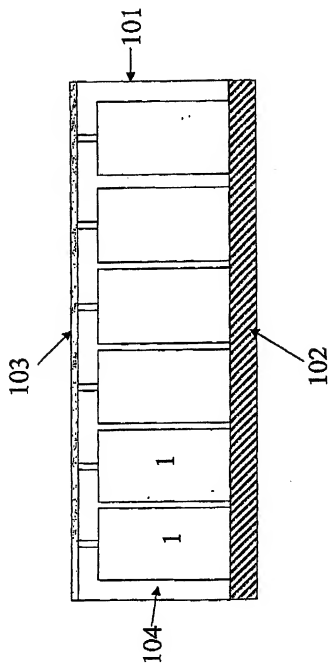


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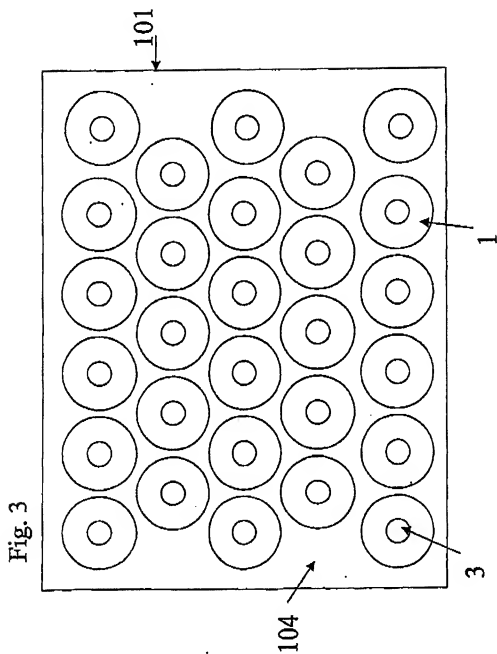
Fig. 2



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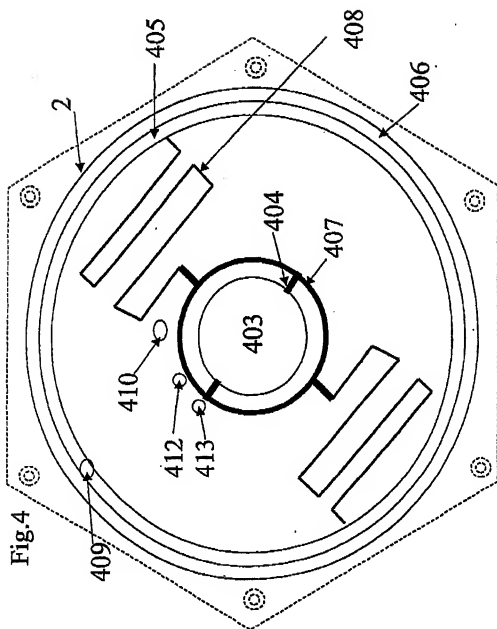
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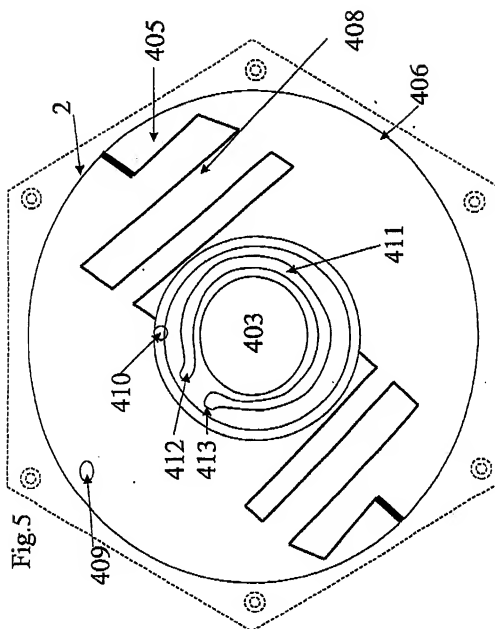
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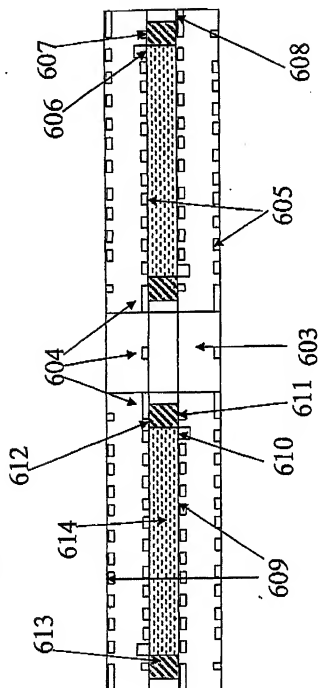


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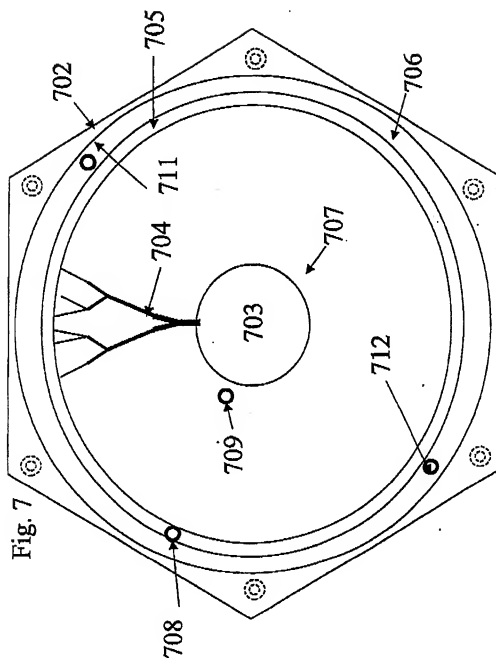
Fig.6



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INTERNATIONAL SEARCH REPORT

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Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practical, search terms used) EPO-Internal, WPI Data, PAJ		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 269 902 A (ELANGOVAN SINGARAVELU ET AL) 14 December 1993 (1993-12-14) claims 1-11; figures 2-4	1-3
A	US 5 595 834 A (NEUTZLER JAY K ET AL) 21 January 1997 (1997-01-21) claims 1-16	1-3
P, A	WO 01 31728 A (ALLIED SIGNAL INC) 3 May 2001 (2001-05-03) claims 1-8	1-3
<input type="checkbox"/> Further documents are listed in the continuation of box C. <input checked="" type="checkbox"/> Patent family members are listed in annex.		
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document (not published on or after the international filing date) "L" document which may interfere (exists on priority claims) or which is cited to establish the publication date of another citation or other applied patent law application "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step unless the document is taken into account "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step unless the document is considered with one or more other such documents, each contribution being obvious to a person skilled in the art "W" document member of the same patent family		
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